Broadcast Signal Lab

IBOC Occupied Bandwidth Case Study

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Topics

- Measuring Power of Digital Waveforms
- IBOC RF Mask
- Digital Intermodulation and Interference

First Thought

- IBOC is amazing
- Measurement issues will be addressed
- Interference issues are minor
  - No FCC standards yet
  - There is time to address
- Nothing in this talk is a deal breaker

Discussing Power

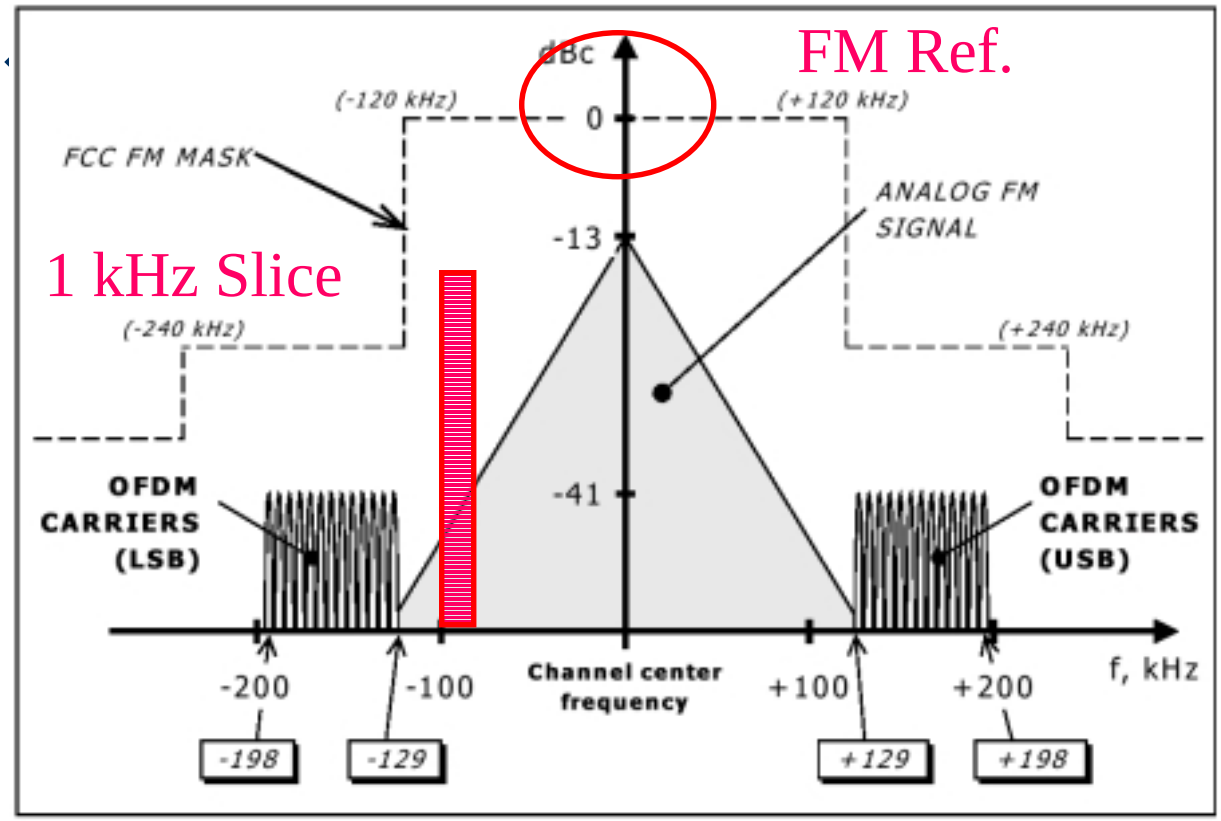


Figure 1. iBiquity FM IBOC system signal spectral power density

Discussing Power

- IBOC Primary Main “subcarriers”
  - Total power 20 dB down (from FM analog)
  - Power in 1 kHz bandwidth 41 dB down

Discussing Power

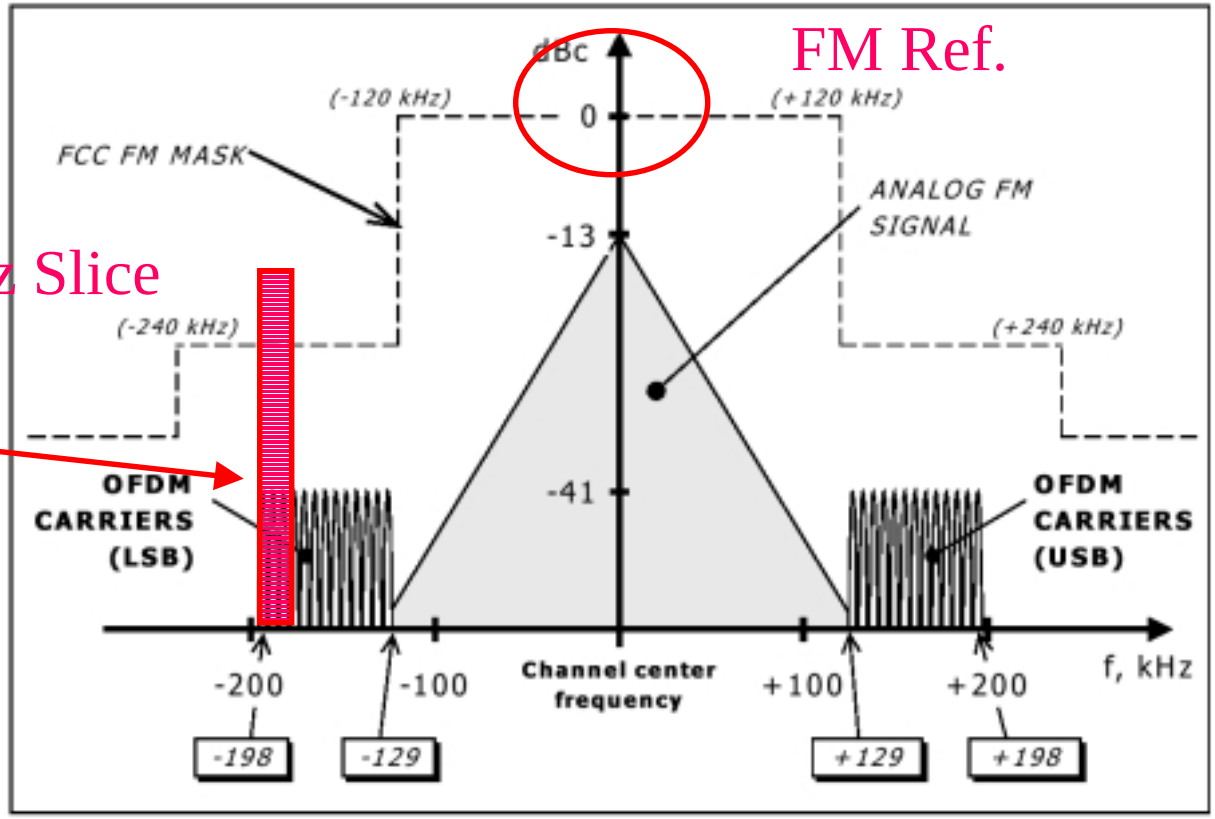


Figure 1. iBiquity FM IBOC system signal spectral power density

Discussing Power

- IBOC Primary Main "subcarriers"
  - Total power 20 dB down (from FM analog)
  - Power in 1 kHz bandwidth 41 dB down
  - System design specification
    - Balances digital performance against interference to analog radios

Discussing Power

- IBOC Primary Main “subcarriers”
  - Linear amplification
  - Push transmitter to compression point for maximum efficiency
  - With compression comes intermodulation

Discussing Power

Midpoints ±164 kHz

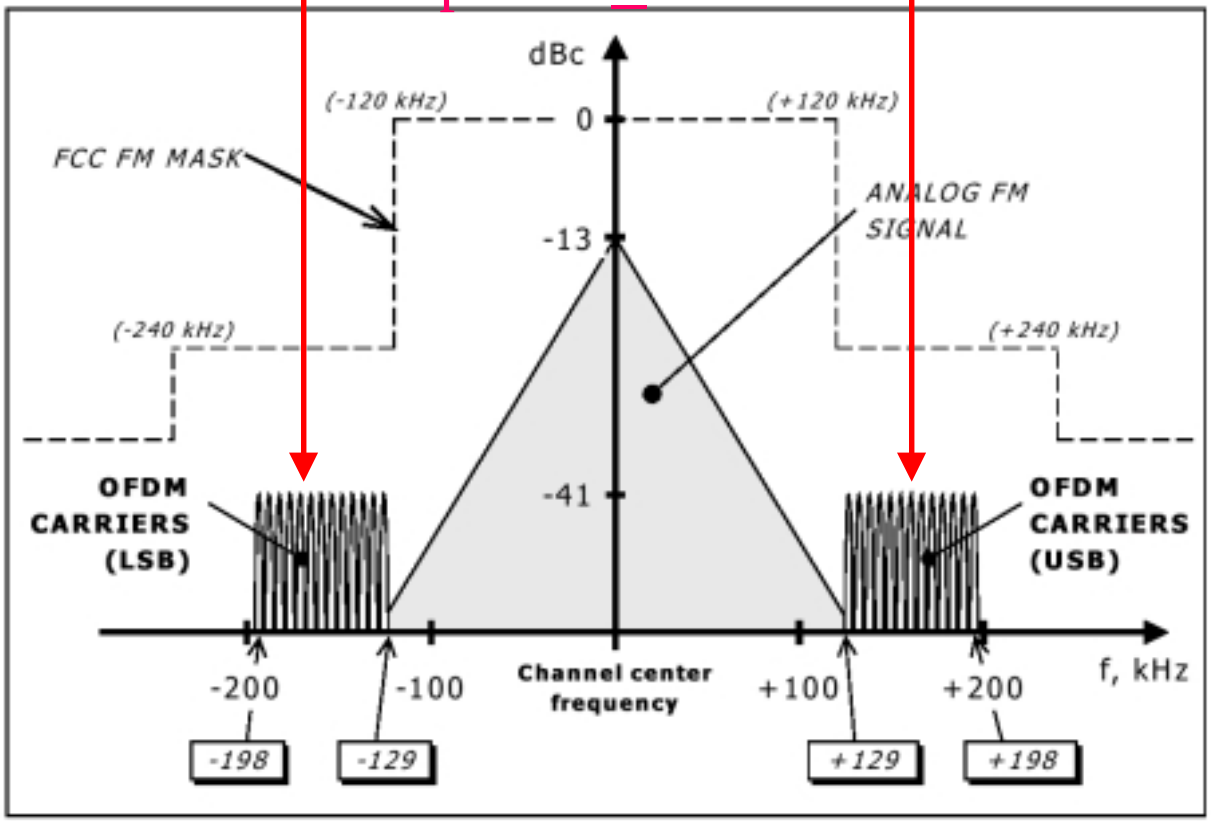
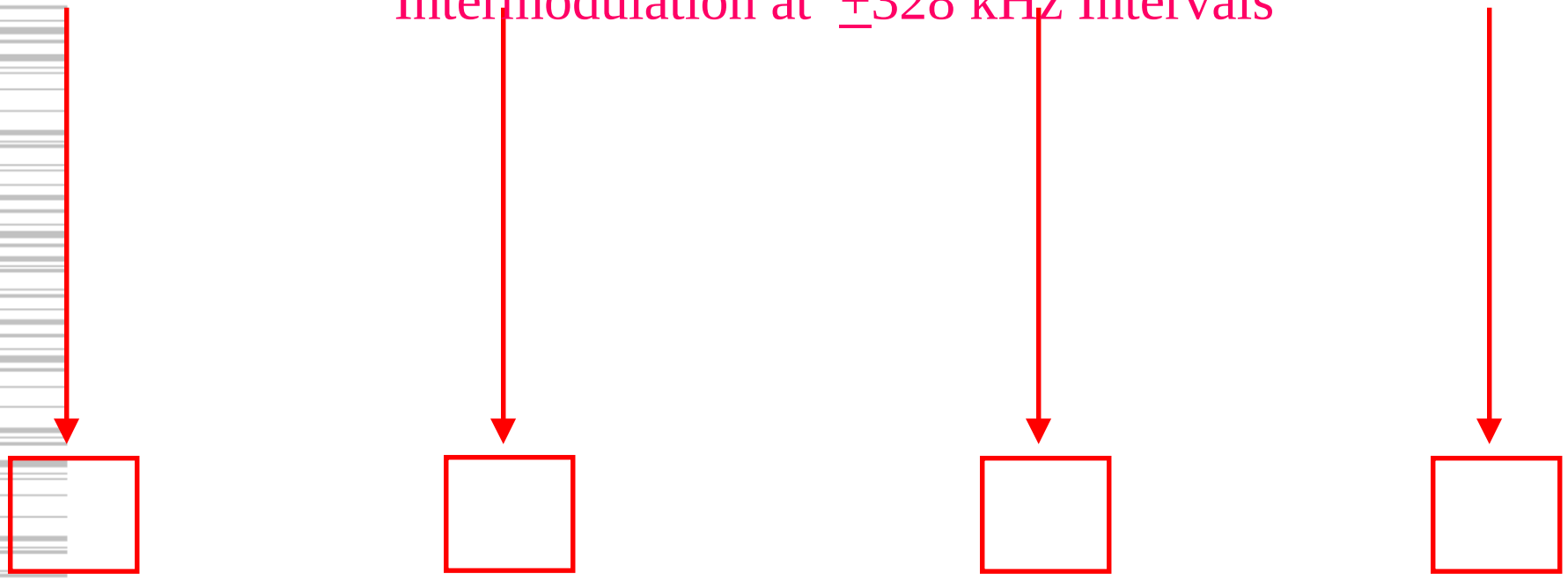


Figure 1. iBiquity FM IBOC system signal spectral power density

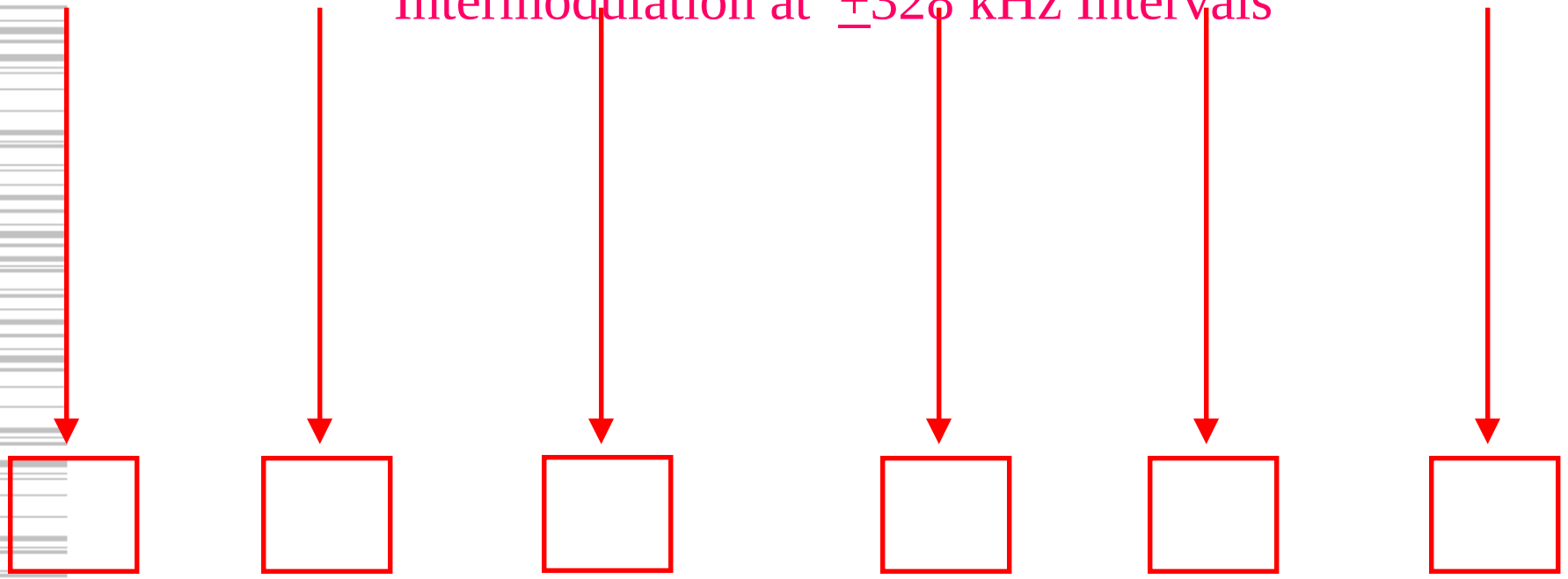
Discussing Power

Intermodulation at ±328 kHz Intervals



Discussing Power

Intermodulation at ±328 kHz Intervals



Discussing Power

What Should this Ratio Be?

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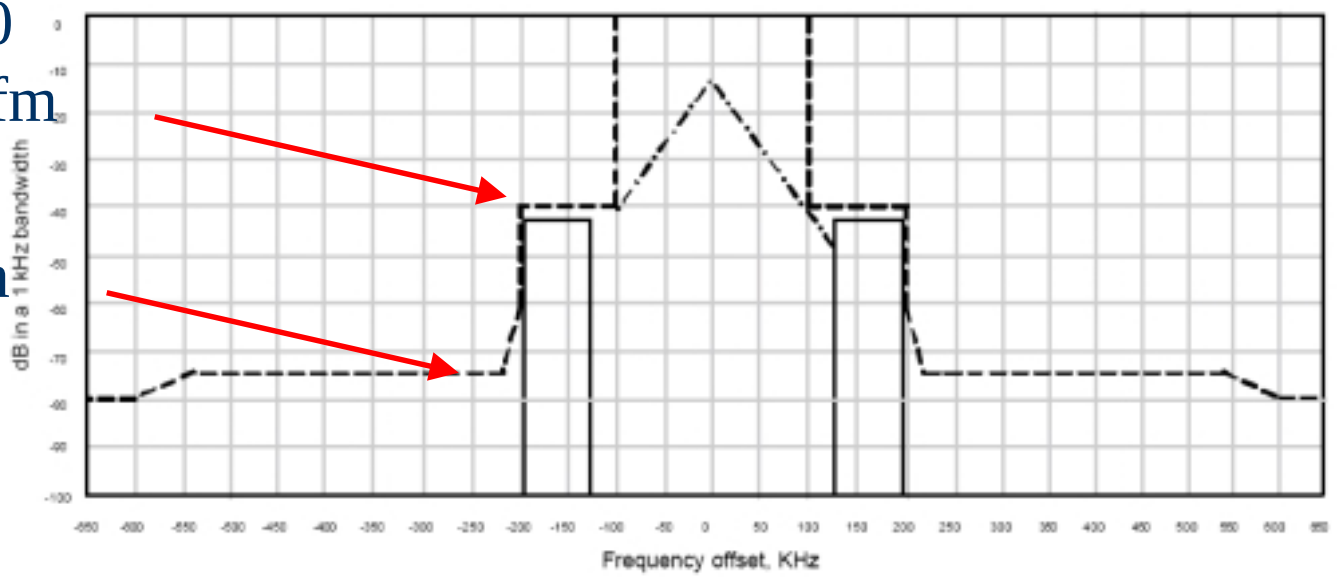
iBiquity RF Mask

-40 dBcfm

-74.4 dBcfm



Frequency, F, Offset Relative to Carrier	Level, dB/kHz
200-215 kHz offset	[-61.4 - (|frequency in kHz|-200 kHz) · 0.867] dB
215-540 kHz offset	-74.4 dB
540-600 kHz offset	[-74.4 - (|frequency in kHz|-540 kHz) · 0.093] dB
>600 kHz offset	-80 dB

Table 3: iBiquity FM Hybrid Mode Noise and Spurious Emission Limits

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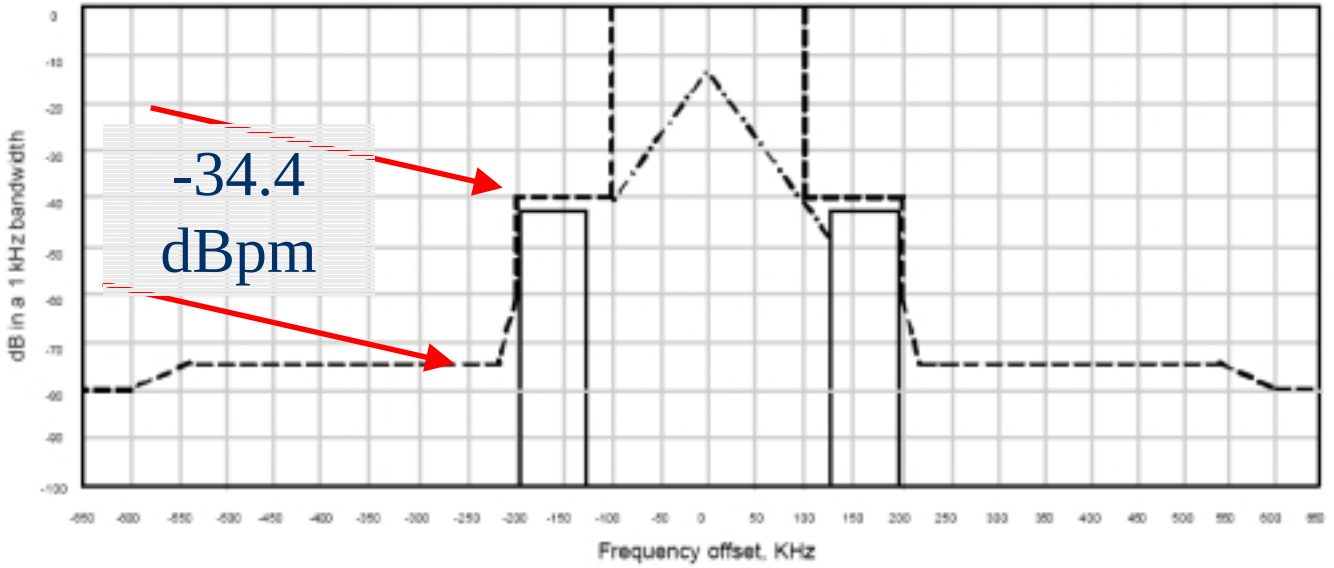
iBiquity RF Mask



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Broadcast Signal Lab

iBiquity RF Mask

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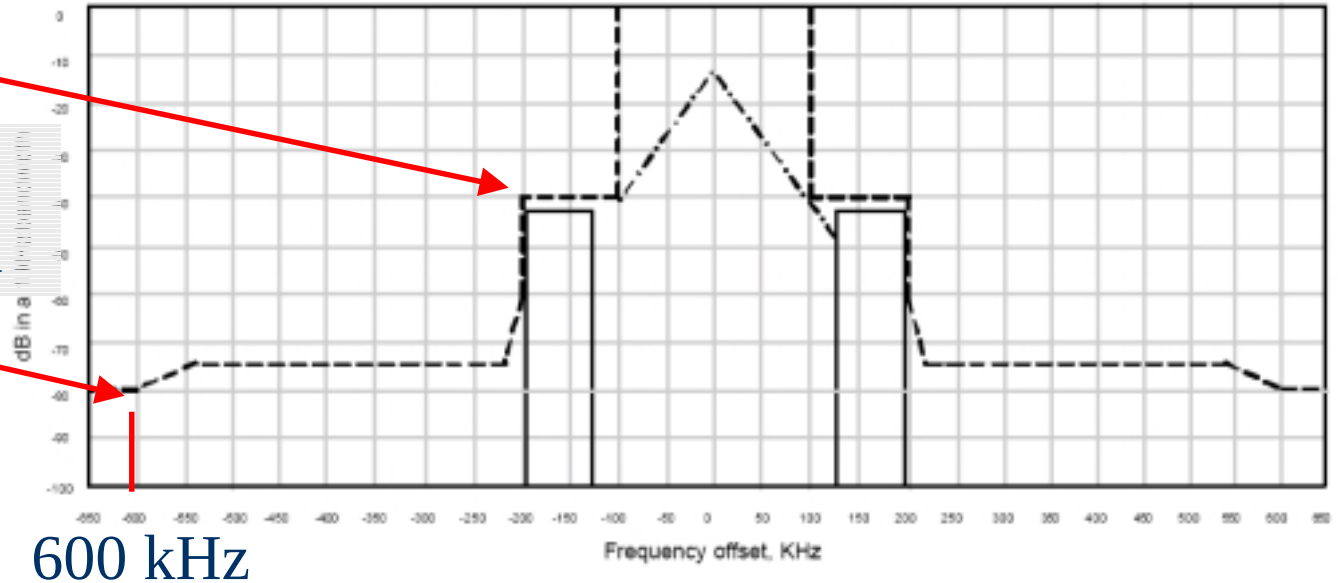

600 kHz

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>600 kHz offset	-80 dB

Table 3: iBiquity FM Hybrid Mode Noise and Spurious Emission Limits

Discussing Power

What Should this Ratio Be?

Answer:

At least 34.4 dB

Disclaimer: Early Production Model
Not at Latest Rev
("Your Mileage May Be Different")

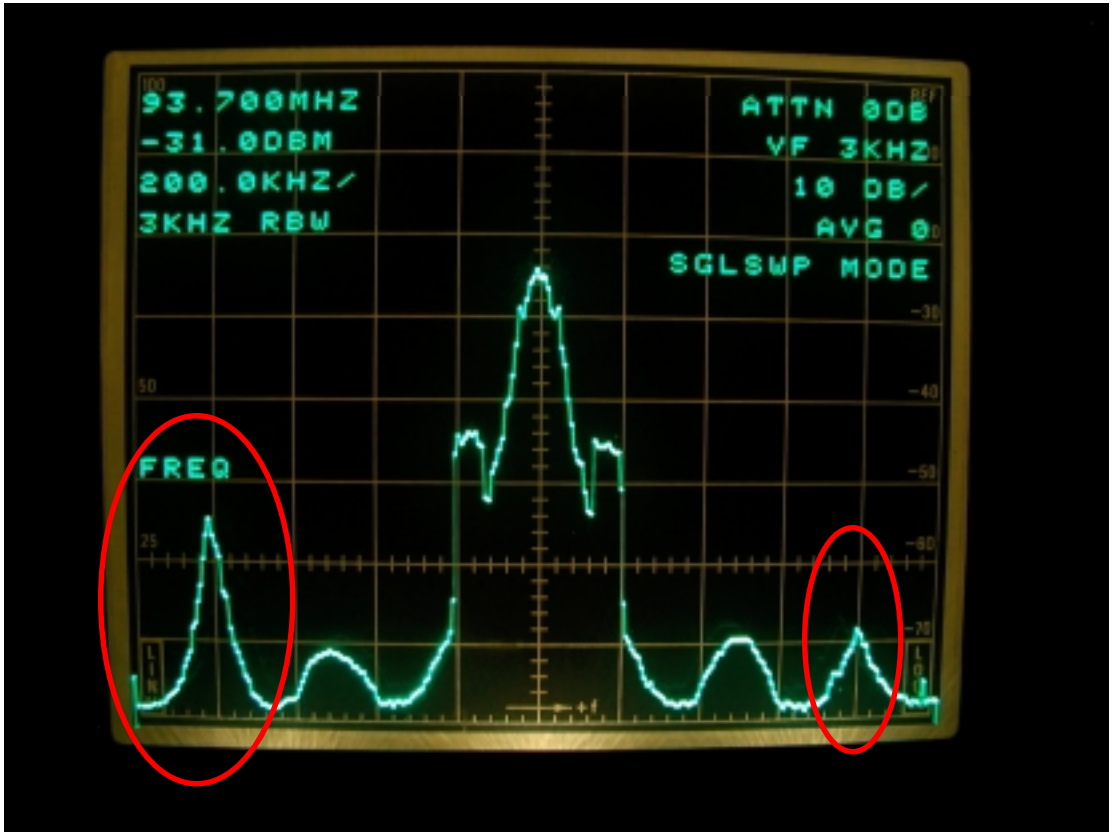
Discussing Power

What Should this Ratio Be?

Answer:

At least 40 dB

Consequences



Consequences

Should Be –80dBcfm in 1kHz

Consequences

More Like –60dBcfm in 100 kHz!

Consequences

Interference area- 4th adjacent

Assume –80 dBcfm spur @ 1kHz BW

Assume total power is -60

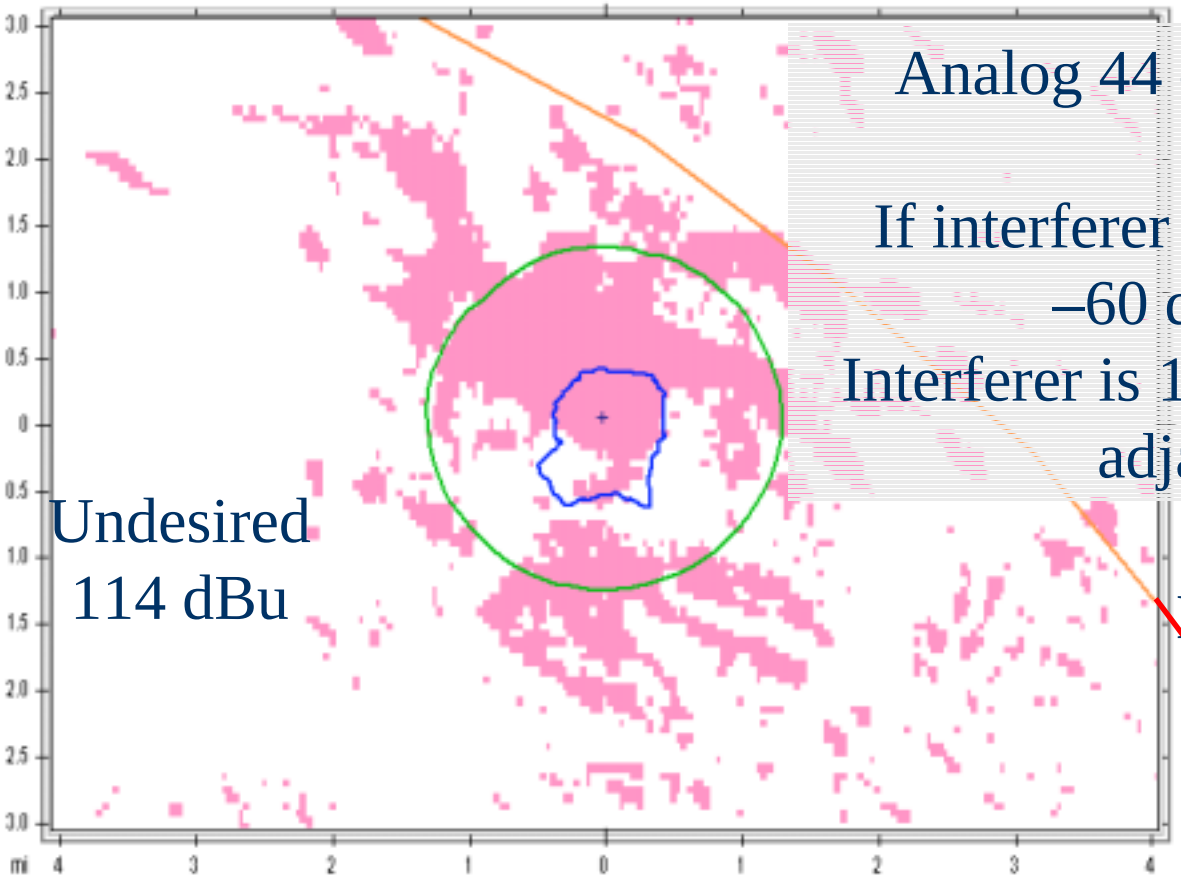
Consider 114 dBu contour of local analog

-60 dB is the 54 dBu of the spur

Assume 70 dBu contour of 4th adjacent

Interferer is only 16 dB below 4th adjacent signal- likely to cause interference

Consequences



Undesired
114 dBu

Desired 70
dBu

Analog 44 dB U/D ratio

If interferer total power is –60 dBcfm,
Interferer is 16 dB below 4th adjacent

Consequences

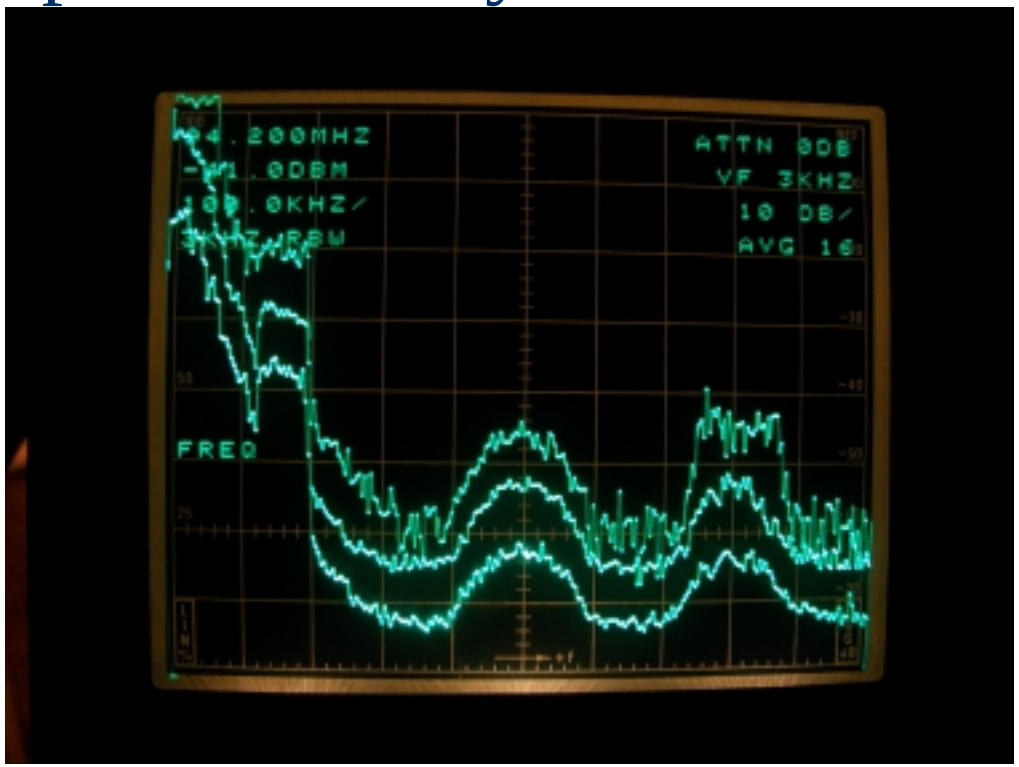
- Recommendation
  - Study this more
  - Evaluate *total power* of spur
  - Establish case-by-case rules

Measurements

- Spectrum analyzers
  - Variations among detectors
  - Variations among detection modes
    - True average of series of random samples
    - Average of Max and Min values in successive traces
    - Video filtering
    - Peak modes

Measurements

- Spectrum analyzers



Peak Hold

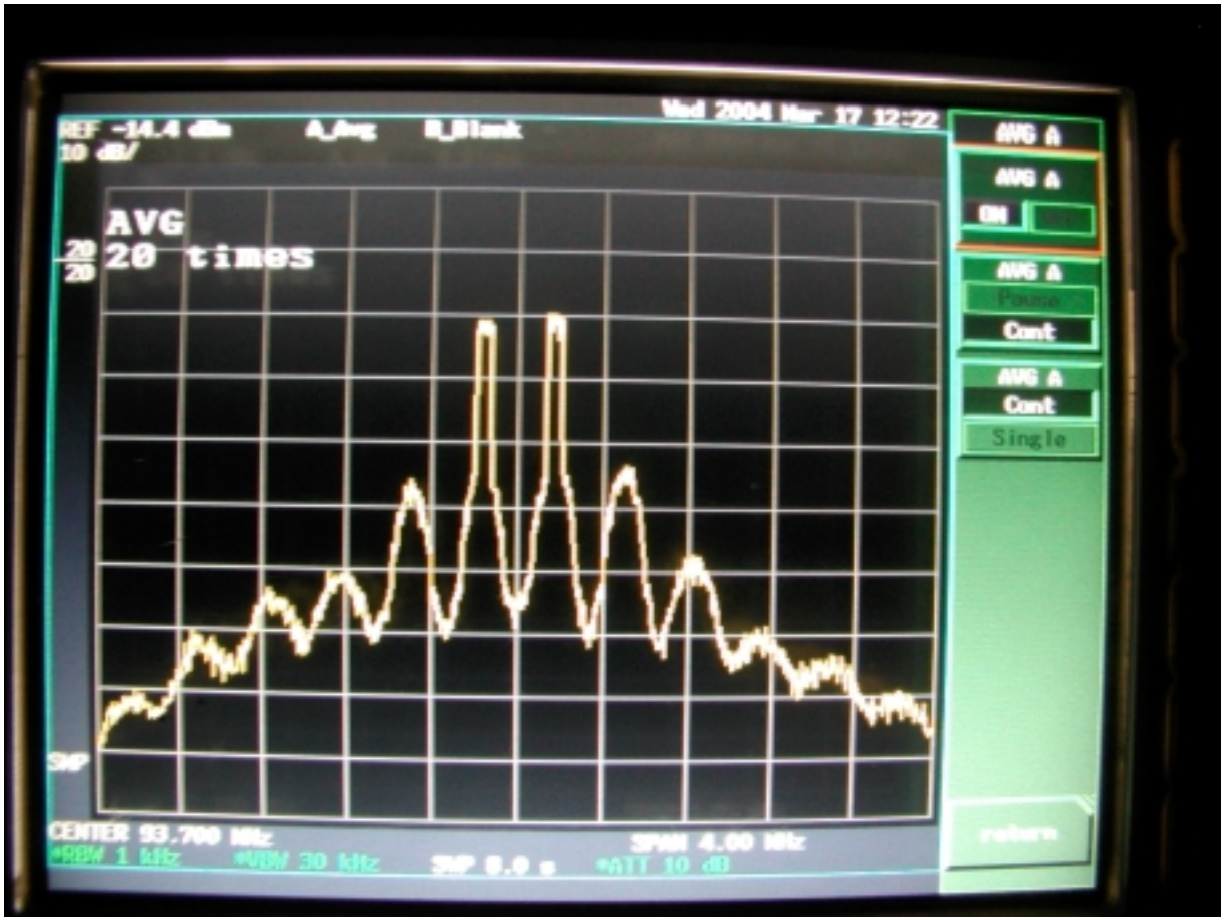
Peak
Average

Max-Min
Average

Measurements

- Where to sample?
  - Exciters quite clean
    - Peak to Average about 7 dB

Measurements



Measurements

- Where to sample?
  - Power Amplifiers compress
    - Peak to average about 5 dB
    - Roughly 2 dB compression
    - Measured with Agilent power meter

Measurements

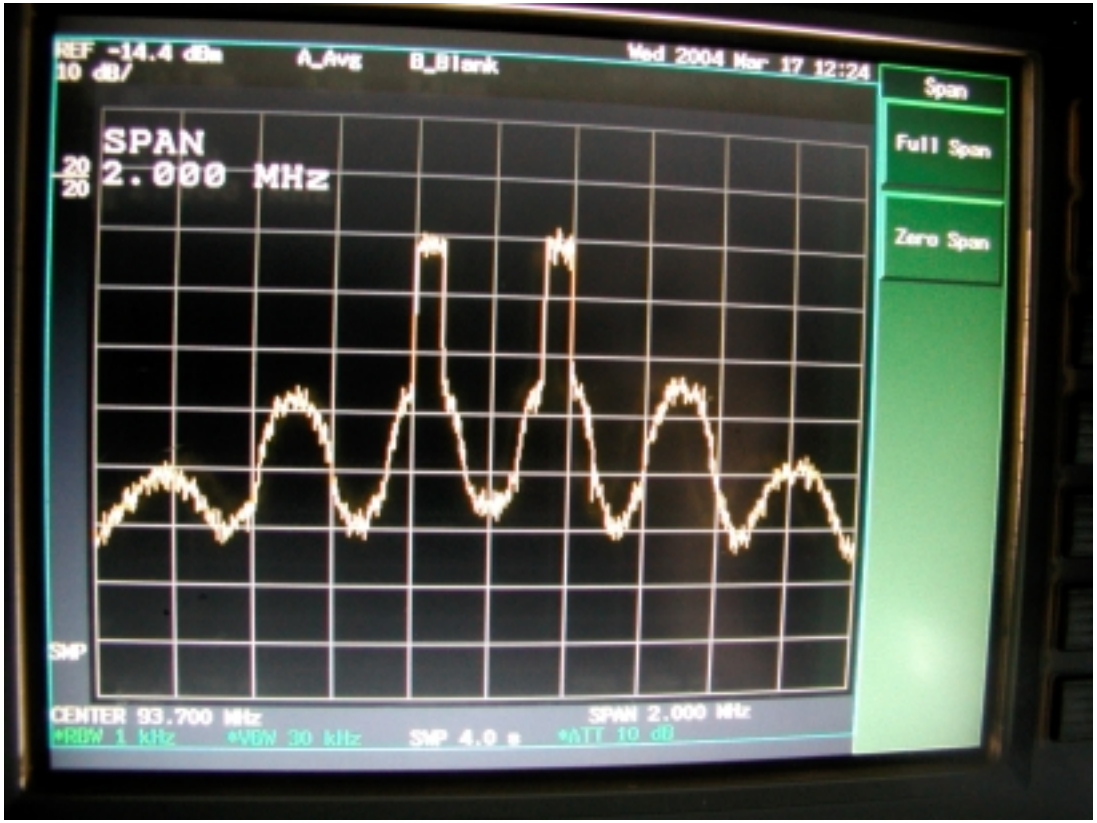
- Where to sample?
  - Sample after PA to see actual spur levels
  - Compare to PM subcarrier levels
  - Antenna bandwidth may reduce spurs somewhat
  - Measurements off air are naturally trickier

Remedies

- Run Class A with lots of headroom
- Filter
- Predistortion

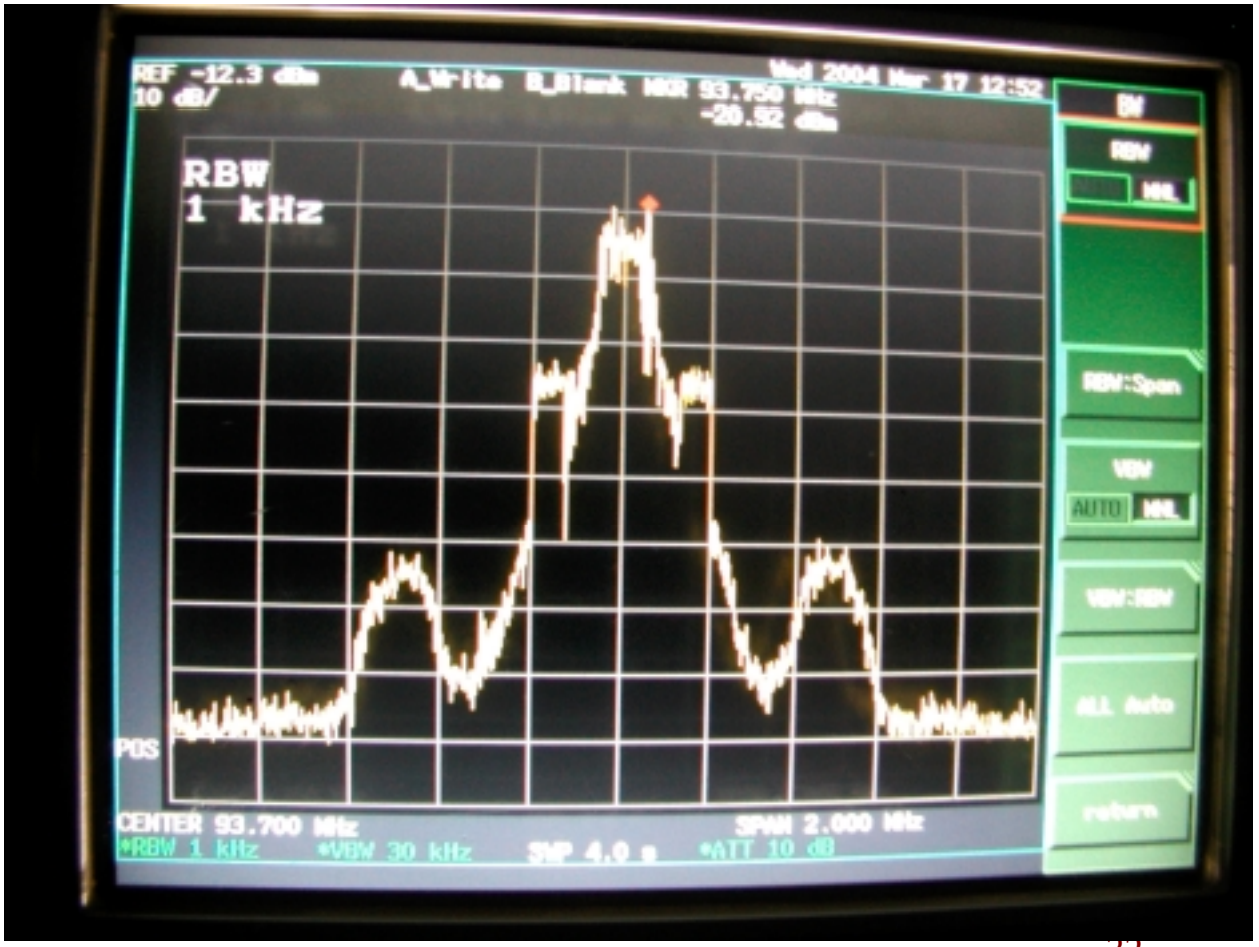
Remedies

- Filter



Remedies

- Filter

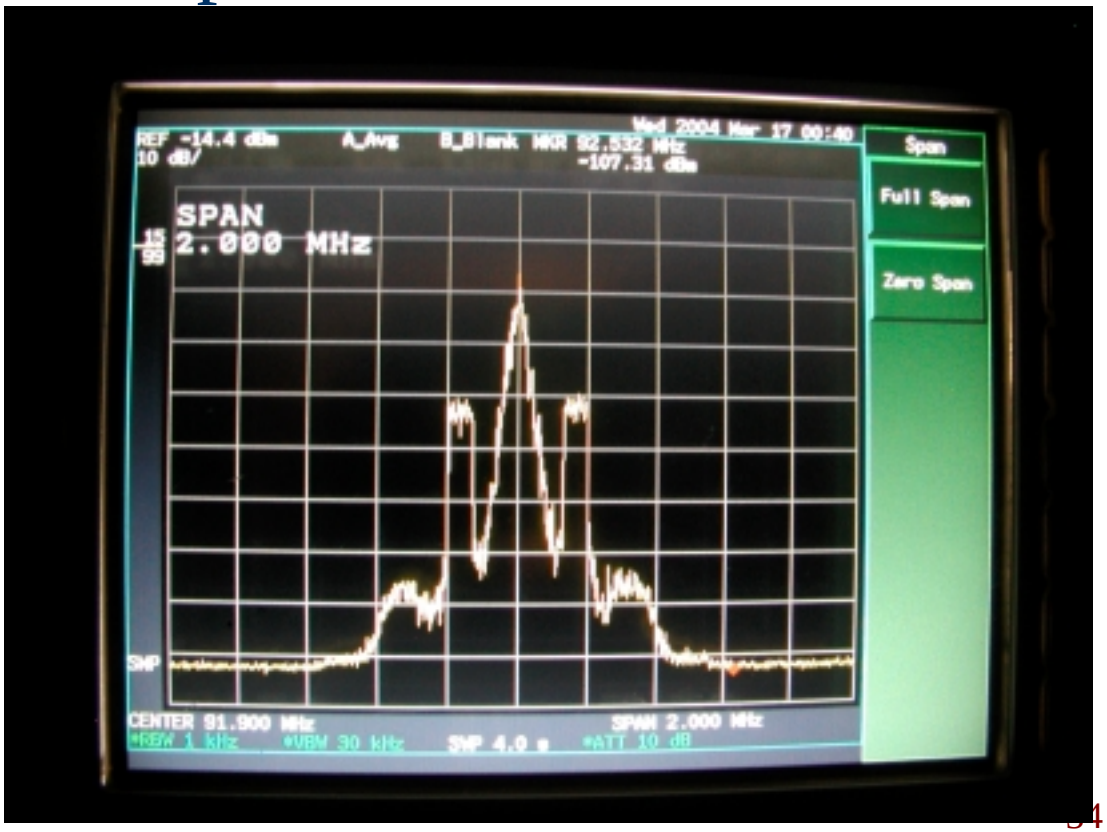


Remedies

- Filter

Remedies

- Common amplification

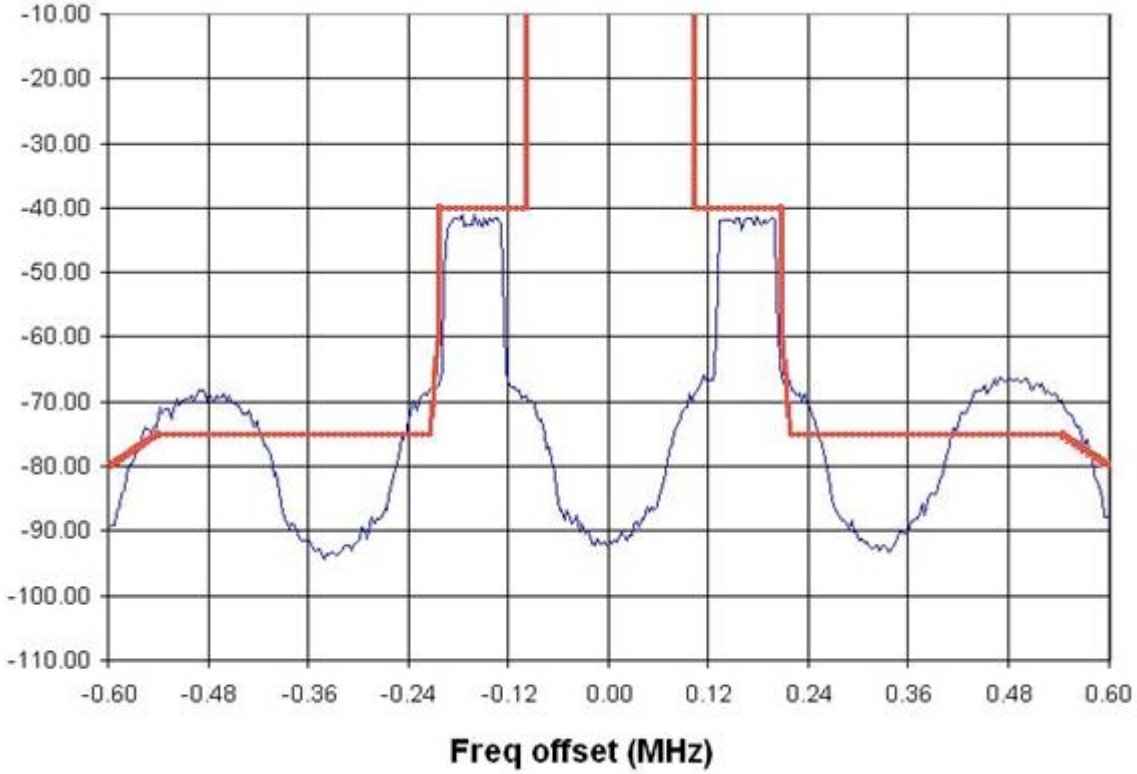


Remedies

- Predistortion
  - Digital
  - Analog
- Manufacturers dealing with this in their designs

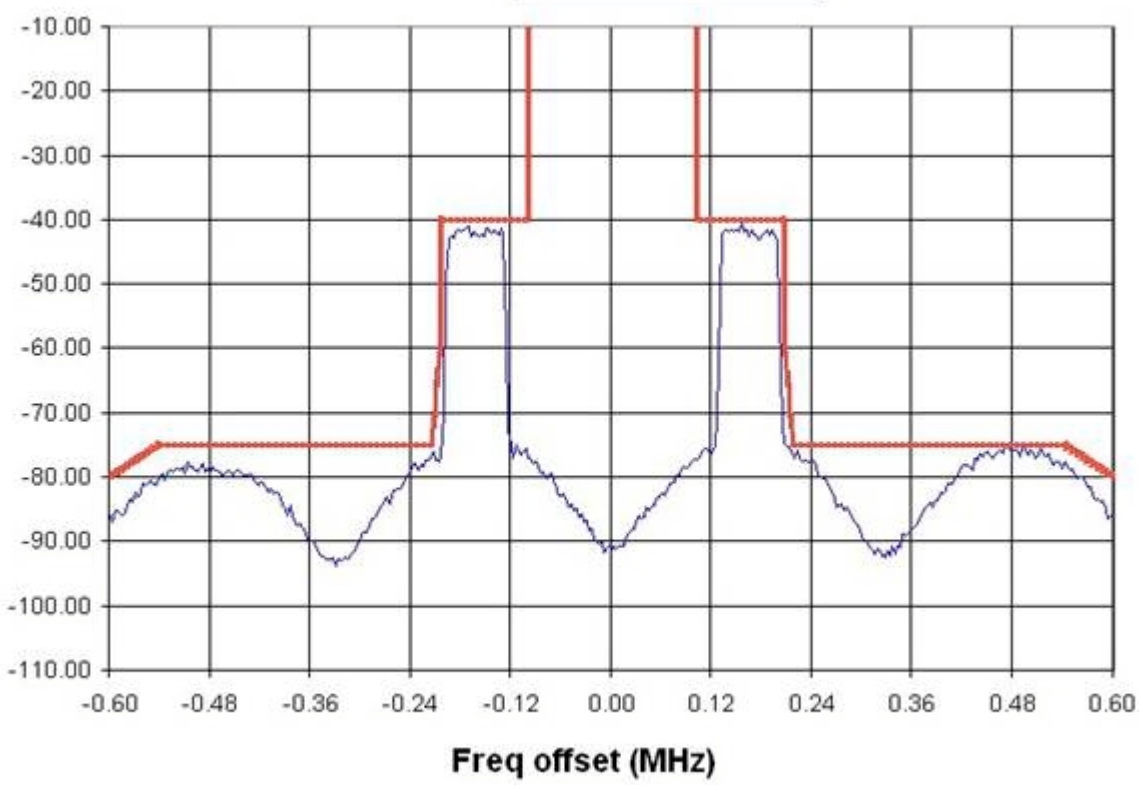
Remedies

- Without Predistortion



Remedies

- With Predistortion



Acknowledgements

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Harris

Broadcast Signal Lab

Thank You

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